

BIRCH, STEWART, KOLASCH & BIRCH, LLP

INTELLECTUAL PROPERTY LAW  
8110 GATEHOUSE ROAD  
SUITE 500 EAST  
FALLS CHURCH, VA 22042-1210  
U S A  
(703) 205-8000

FAX: (703) 205-8050  
(703) 698-8590 (G IV)

e-mail: mailroom@bskb.com  
web: http://www.bskb.com

CALIFORNIA OFFICE:  
COSTA MESA, CALIFORNIA

THOMAS S. AUCHTERLONIE  
MICHAEL R. CAMMARATA  
JAMES T. ELLER, JR.  
SCOTT L. LOWE  
MARK J. NUEL, Ph D  
DARIN E. BARTHOLOMEW  
D. RICHARD ANDERSON  
PAUL C. LEWIS  
W. KARL RENNER  
MARK W. MILSTEAD\*  
JOHN CAMPA\*

REG. PATENT AGENTS  
FREDERICK R. HANDRE  
ANDREW J. TELESZ, JR.  
MARYANNE ARMSTRONG, Ph D  
MAKI HATSUMI  
MIKE S. RYU  
CRAIG A. McROBBIE  
GARTH M. DAHLEN, Ph D  
LAURA C. LUTZ  
ROBERT E. GOOZNER, Ph D  
HYUNG N. SOHN  
MATTHEW J. LATTIG  
ALAN PEDERSEN-GILES  
JUSTIN D. KARJALA  
C. KEITH MONTGOMERY

TERRELL C. BIRCH  
RAYMOND C. STEWART  
JOSEPH A. KOLASCH  
JAMES M. SLATTERY  
BERNARD L. SWEENEY\*  
MICHAEL K. MUTTER  
CHARLES GORENSTEIN  
GERALD M. MURPHY, JR.  
LEONARD R. SVENSSON  
TERRY L. CLARK  
ANDREW D. MEIKLE  
MARC S. WEINER  
JOE MCKINNEY MUNCY  
ROBERT J. KENNEY  
DONALD J. DALEY  
JOHN W. BAILEY  
JOHN A. CASTELLANO, III  
GARY D. YACURA  
OF COUNSEL:  
HERBERT M. BIRCH (1905-1996)  
ELLIOT A. GOLDBERG\*  
WILLIAM L. GATES\*  
EDWARD H. VALANCE  
RUPERT J. BRADY (RET.)\*

\*ADMITTED TO A BAR OTHER THAN VA.

Date: April 26, 2000  
Docket No.: 0054-0205P-SP

Assistant Commissioner for Patents  
Box PATENT APPLICATION  
Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of  
Inventor(s): BOBER, Miroslaw Z.

For: METHOD AND APPARATUS FOR REPRESENTING AND SEARCHING FOR AN  
OBJECT USING SHAPE

Enclosed are:

- ☒ A specification consisting of 16 pages
- ☒ 5 sheet(s) of Formal drawings
- ☒ An assignment of the invention (2)
- ☐ Certified copy of Priority Document(s)
- ☒ Executed Declaration ☒ Original ☐ Photocopy
- ☐ A verified statement to establish small entity status under 37  
CFR 1.9 and 37 CFR 1.27
- ☒ Preliminary Amendment
- ☐ Information Disclosure Statement, PTO-1449 and reference(s)

Other \_\_\_\_\_

The filing fee has been calculated as shown below:

LARGE ENTITY				SMALL ENTITY	
FOR	NO. FILED	NO. EXTRA	RATE FEE		RATE FEE
BASIC FEE	***** ***** *****	***** ***** *****	***** ***** \$690.00 *****	or	**** **** \$345.00 ****
TOTAL CLAIMS	15 - 20 =	0	x18 =\$ 0.00	or	x 9 = \$ 0.00
INDEPENDENT	3 - 3 =	0	x78 =\$ 0.00	or	x 39 = \$ 0.00
MULTIPLE DEPENDENT CLAIM PRESENTED			+260 = \$ 0.00	or	+130 = \$ 0.00
TOTAL \$ 690.00				TOTAL \$ 0.00	

X A check in the amount of \$ 730.00 to cover the filing fee and recording fee (if applicable) is enclosed.

\_\_\_\_\_ Please charge Deposit Account No. 02-2448 in the amount of \$ \_\_\_\_\_. A triplicate copy of this transmittal form is enclosed.

\_\_\_\_\_ No fee is enclosed.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. 1.16 or under 37 C.F.R. 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By \_\_\_\_\_

MICHAEL K. MUTTER

Reg. No. 29,680

P. O. Box 747

Falls Church, Virginia 22040-0747

(703) 205-8000  
MKM/dpt

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: BOBER, Mirosław Z.  
Appl. No.: NEW Group: UNKNOWN  
Filed: April 26, 2000 Examiner: UNKNOWN  
For: METHOD AND APPARATUS FOR REPRESENTING AND  
SEARCHING FOR AN OBJECT SHAPE

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents  
Washington, DC 20231

April 26, 2000

Sir:

The following preliminary amendments and remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE CLAIMS:

Please cancel claim(s) 16 and 17 without prejudice or disclaimer to the subject matter contained therein.

Please amend the claims as follows:

**CLAIM 3:** Line 1, delete "or claim 2"

**CLAIM 5:** Line 1, delete "or claim 4"

**CLAIM 6:** Line 6, change "any on of claims 1 to 4" to

--claim 1--

**CLAIM 7:** Line 1, delete "dependent on claim 1 or claim 2"

**CLAIM 9:** Line 1, change "any one of claims 6 to 8" to

--claim 6--

Line 2, after "include" insert --the derived--

Line 2 and 3, delete "derived in accordance with  
a method as claimed in claim 3"

**CLAIM 10:** Line 1, change "any one of claims 6 to 9" to

--claim 6--

**CLAIM 12:** Line 2, change "any one of claims 1 to 11" to

--claim 1--

**CLAIM 13:** Line 2, change "any one of claims 1 to 11" to

--claim 1--

**CLAIM 14:** Line 2, change "any one of claims 1 to 11" to

--claim 1--

**CLAIM 15:** Line 3, change "any one of claims 1 to 11" to

--claim 1--

REMARKS

The amendment to the claims is to delete multiple dependencies in order to place the application in better form prior to examination.

Entry of the present amendment and favorable action on the above-identified application is respectfully requested.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By 

Michael K. Mutter, #29,680

MKM/dpt  
0054-0205P

P.O. Box 747  
Falls Church, VA 22040-0747  
(703) 205-8000

(Rev. 04/19/2000)

Method and Apparatus for Representing and Searching for an ObjectUsing Shape

The present invention relates to a method and apparatus for representing  
5 an object in a still or video image using shape, especially for use in searching.  
The invention also relates to a method and apparatus for searching for an object  
in a image using a shape representation.

It is known to store still or video images, for example in image libraries,  
using representations of objects appearing in images. The representations are  
10 used in searching methods to enable images containing objects of interest to be  
retrieved. The representations may be based on various features of the objects,  
including colour, texture and shape.

Various methods for representing shapes of objects in images are  
known. Known methods include chain coding, the quad-tree method and the  
15 curvature scale space representation method.

To perform a search in a image searching system, a user inputs a query  
by presenting the system with a sketch or image of the object sought, or by  
selecting a view of an object stored on the system. The system then derives or  
obtains a representation of the query object and compares the query  
20 representation with the representations of images stored in the database using  
an appropriate matching method. The closest matches are displayed on a  
display unit.

In most cases, an object as it appears in a video image is a projection of a 3-dimensional real object onto a 2-dimensional image plane. The 2-dimensional shape or outline of an object appearing in an image thus depends on factors such as the viewing position, viewing angle and camera and optical system parameters. Objects will therefore have different outlines associated with different views.

A disadvantage of known image database systems is that different views of an object having different outlines are treated as different objects. As a result, for example, if a user inputs a query based on a front view of an object A, and the object A only appears in a video sequence from the rear and side view, no successful matches will result and the object will not be retrieved.

The present invention provides a method of representing an object appearing in a digital image comprising deriving representations of a plurality of different 2-dimensional views corresponding to the object.

The invention also provides a method of matching objects comprising inputting a query and comparing the query with the plurality of representations of different views of objects to find the closest match or matches, by processing signals corresponding to images of objects.

An embodiment of the invention will be described with reference to the accompanying drawings of which:

Fig. 1 is a block diagram of a system according to an embodiment of the invention;

Fig. 2 is a diagram showing how a descriptor for an object is obtained;

Fig. 3 is a flowchart illustrating how a descriptor for an object is obtained;

Fig. 4 is a diagram illustrating an apparatus and method for searching;

5 Fig. 5 is a flowchart illustrating a search method.

A system according to an embodiment of the invention is shown in Fig.

1. The system includes a control unit 2 such as a computer for controlling operation of the system, a display unit 4 such as a monitor, connected to the control unit 2, for displaying outputs including images and text, and a pointing  
10 device 6 such as a mouse for inputting instructions to the control unit 2. The system also includes an image database 8 storing digital versions of a plurality of video sequences and a descriptor database 10 storing descriptor information, described in more detail below, for objects appearing in each of the video sequences stored in the image database 8. Each of the image database 8 and  
15 the descriptor database 10 is connected to the control unit 2.

In this embodiment, the elements of the system are provided on a single site, such as an image library, where the components of the system are permanently linked.

A method of deriving a descriptor for an object according to an  
20 embodiment of the invention will be described with reference to Figs. 2 and 3. The method will be described for an object having a relatively simple shape, in this case a cylindrical object.



In this example, in a video sequence stored in the image database 8, the cylindrical object appears twice. Referring to Fig. 2, in the first appearance, the object outline corresponds to view 1, that is a view from the side and in the second appearance, the object outline corresponds to view 3, that is a perspective view from the side and above.

The steps of the method will now be described with reference to the flowchart shown in Fig. 3.

The database indexer recognises that the two outlines are of the same object and that the 3-dimensional object corresponding to those outlines is a cylinder (step 10). For each of view 1 and view 3, shape descriptors using the curvature scale space (CSS) representation are derived (step 20). Also, the database indexer selects any additional views that are deemed representative of the object, even if they do not appear in the video sequence under consideration (step 30). In this example, view 2, which is a view of a cylinder from above, is selected as representative. A CSS representation of that view is also obtained (step 40).

The paper "Robust and Efficient Shape Indexing through Curvature Scale Space" by Farzin Mokhtarian, Sadegh Abbassi and Josef Kittler, Proc. British Machine Vision Conference, pp. 53-62, Edinburgh, U.K. 1996 describes a method of curvature scale space representation and is incorporated herein by reference. Briefly, a curve representing the outline of a shape is evolved by smoothing the curve. The curve is considered at a number of

different stages in the evolution. More specifically, the curvature zero crossings are identified in a curvature function at each of the stages of the evolution. A graph of the curvature zero crossings is obtained by combining zero crossing from all stages of the evolution. One axis of the graph  
5 corresponds to  $\sigma$  which represents the evolution parameter of the curve and the other axis corresponds to a curve arc length parameter  $u$ . A shape is then represented by the locations of the maxima of the contours in the graph.

In addition to CSS shape representations of representative views of the object, a global 3D shape parameter of the object, which is independent of the  
10 view of the object, is obtained (step 50). In this example, the global parameter is the volume of the object in real life. The volume may already be known, or it may be approximated with reference to other objects appearing in the video sequence, such as people, for which dimensions can be approximated.

The global parameter and the view shape descriptors are combined to  
15 form a 3D object shape descriptor (step 60).

3D object shape descriptors are obtained in the above manner for all objects of interest appearing in images in the image database 8. The number of views for any given object and which views are used depends on the complexity of the object. Some objects may have no global parameter in the  
20 3D object shape descriptor, for example, if a value for a volume is not known or not easily derived. Each view has a reference pointer indicating in which frame in the video sequence it appears, and also which object in the frame it is,

for example, a view of an object may have a pointer indicating that it appears in frame 1000 and it is object number 3.

In other embodiments using different shape representation methods, the number and nature of the views will also depend on the shape representation method used. For example, a method that is less sensitive to shape deformation resulting from changes in viewing geometry will require a smaller number of views.

The descriptor database 10 stores the 3D object shape descriptors for the objects in video sequences stored in the image database 8.

10 A method of searching for an object in a video sequence will now be described with reference to Figs. 4 and 5.

The user initiates a search by inputting a query. The query is input by using the pointing device 6 to draw one or more shape outlines on the display unit 4 (step 62). In this example, two query outlines 100 are input. These are the query views. The user also inputs a parameter representing the volume of the object for which he is searching (step 64).

The control unit 2 then derives the CSS view descriptor for each of the query views (step 66).

In an alternative embodiment, the user inputs a query by selecting a query shape or shapes from a menu of shapes displayed on the display unit 4 by the control unit 2. In such an embodiment, the view descriptors may already be available in the descriptor database 10.

The query volume parameter and the query view descriptors are combined to form a query 3D object descriptor.

The system then performs a matching procedure for determining the similarity between the query object descriptor and the object descriptors stored in the descriptor database 10, hereinafter described as model object descriptors. Each model object descriptor in the descriptor database is selected in turn by a selector 205 (step 68) and the following steps are performed for each model object descriptor in its turn.

Firstly, a global similarity measure GS is obtained (step 70) by a comparator 200, using the global parameters for the query object descriptor and the model object descriptor. In this embodiment, the GS is derived by taking the ratio of the query volume parameter to the model volume parameter for the descriptor taken from the database. If the ratio is in the interval  $(1/c, c)$  where  $c > 1$ , then the objects are considered similar and GS takes the value 0. Otherwise, GS takes the value infinity. The value of  $c$  depends on the application. For example, for feature film,  $c = 5$ .

If at least one of the query object descriptor and the model object descriptor does not have a global parameter value, then  $GS = 0$ .

If  $GS \neq 0$  then a new model object descriptor is selected from the descriptor database; if  $GS = 0$ , then a view descriptor comparison is performed as follows (step 72).

Each query view descriptor is compared with each view descriptor for the model object descriptor under consideration in a comparator 810 using a matching function to derive view-similarity measures (step 74). A comparison of the  $i$ th query view descriptor and the  $j$ th model view descriptor results in a  
 5 view similarity measure  $s_{ij}$ .

In more detail, the query view descriptor is selected using a selector 600 and the database view descriptor is selected using a selector 700. Firstly, the view descriptor for the first query view is compared with each view descriptor in the model object descriptor from the database. For each pair, a view-  
 10 similarity value  $s$  is computed, using a suitable matching algorithm. In this embodiment, a view-similarity value  $s$  is computed using the matching algorithm described in the Mokhtarian, Abbasi and Kittler paper described above. When this particular similarity measure is used, the smaller the view similarity values, the closer is the match. This results in a set of  $k$  view-  
 15 similarity measures for the first query view, where  $k$  is the number of view descriptors in the model object descriptor under consideration, and the  $k$  measures are stored in a global and local similarity combiner 820.

Then view-similarity values are computed and stored for the second query view descriptor and the model view descriptors from the database in the  
 20 same way, resulting in  $k$  further view-similarity measures.

For each query view, the minimum view-similarity value for the database descriptor value under consideration is selected (step 76). This

minimum value is a measure of the closest match between the respective query view and one of the views in the object descriptor being considered. This results in  $p$  minimum view-similarity values where  $p$  is the number of query views. In this example,  $p=2$ .

5           An overall similarity measure  $S$  for the query descriptor and the model object descriptor being considered is taken as the median of the  $p$  similarity values (step 78). This represents the closeness of the match between the query descriptor and the model object descriptor taking all views into account. Thus, if one query view matches a view in the database descriptor closely but the  
10           other query view does not match any view in the database descriptor closely, then this is reflected in  $S$  by an intermediate value.

          The above steps are repeated for each object descriptor in the descriptor database 8, resulting in  $n$  similarity measures  $S$ , where  $n$  is the number of 3D object descriptors in the descriptor database (step 80). The  $n$  similarity  
15           measures are then ordered (step 82) starting from the lowest value which indicates the closest match. The  $m$  lowest values, where  $m$  is a value selected by the user or determined by the set-up of the control unit, are then selected, and an image from each of the corresponding  $m$  video sequences including the object is displayed on the display unit 4 (step 84).

20           According to the invention, multiple views of a single object are stored to form a complete or quasi-complete description of the outline shape. The representation may be quasi-complete if only views considered important for

retrieval are stored. For example, for a typical database storing feature films, only front, back, side and top views of a car may be stored as a unified representation, but the view from under the car is not stored, as it is unlikely that that view will be used as a query.

5           A system according to the invention may, for example, be provided in an image library. Alternatively, the databases may be sited remote from the control unit of the system, connected to the control unit by a temporary link such as a telephone line or by a network such as the internet. The image and descriptor databases may be provided, for example, in permanent storage or on  
10           portable data storage media such as CD-ROMs or DVDs.

Components of the system as described such as the selectors and comparators may be provided in software or hardware form. Although the invention has been described in the form of a computer system, it could be implemented in other forms, for example using a dedicated chip.

15           Specific examples have been given of methods of representing a 2D shape of an object and of methods for calculating values representing similarities between two shapes but any suitable such methods can be used.

          The various views of an object making up the complete or quasi-complete shape description may, for example, be provided by the film  
20           producer. For example, in a film including a car, the producer may arrange for 20 different views of the car to be shot for use in indexing the film in the database. Alternatively, a link may be provided between all the different views

of an object in a sequence to enable the views to be found, and the shape for any useful views not appearing in the sequence may, for example, be provided when data for the first view of the object is included.

The invention can also be used, for example, for matching images of  
5 objects for verification purposes, or for filtering.



Claims

1. A method of representing an object appearing in a still or video image, wherein the object appears in the image with a first two-dimensional outline, by processing signals corresponding to the image, the method comprising deriving a view descriptor of the first outline of the object and deriving at least one additional view descriptor of the outline of the object in a different view, and associating the two or more view descriptors to form an object descriptor.
2. A method as claimed in claim 1 wherein the view descriptors are derived using a curvature scale space representation.
3. A method as claimed in claim 1 or claim 2 further comprising deriving a descriptor of the object which is related to the shape and/or size of the object and which is independent of the view of the object in the image.
4. A method of representing an object appearing in a still or video image comprising deriving a descriptor which is related to the shape and/or size of the object and which is independent of the view of the object in the image.

5. A method as claimed in claim 3 or claim 4 wherein said view-independent descriptor corresponds to the volume of the object.

6. A method of searching for an object in still or video images by  
5 processing signals corresponding to images, the method comprising inputting a query to the computer in the form of at least one two-dimensional outline of an object, deriving a descriptor of the query object, comparing said query descriptor with stored descriptors for objects in images derived in accordance with a method as claimed in any one of claims 1 to 4 and selecting and  
10 displaying at least one result corresponding to an image containing an object for which the comparison between the respective descriptor and the query descriptor indicates a degree of similarity between the query and said object.

7. A method as claimed in claim 6 dependent on claim 1 or claim 2  
15 wherein a query is input in the form of two or more two-dimensional outlines of an object, and wherein a query view descriptor is derived for each said outline, and wherein the step of comparing comprises comparing each said query view descriptor with each view descriptor in each stored object descriptor to derive a plurality of view-similarity values.

20

8. A method as claimed in claim 6 wherein the view-similarity values are analyzed to derive object similarity values.

9. A method as claimed in any one of claims 6 to 8 wherein at least some of the object descriptors include view-independent descriptors derived in accordance with a method as claimed in claim 3 and wherein the method comprises inputting a view-independent query value and the step of comparing  
5 compares the query value with the view-independent descriptors for the stored object descriptors.

10. A method as claimed in any one of claims 6 to 9 wherein the query descriptor is derived using a curvature scale space representation of the  
10 query object outline.

11. A method of representing an object appearing in a image by processing signals corresponding to said image, the method comprising deriving representations of a plurality of different 2-dimensional views  
15 corresponding to the object.

12. An apparatus adapted for implementing a method as claimed in any one of claims 1 to 11.

20 13. A computer program for implementing a method as claimed in any one of claims 1 to 11.

14. A computer system programmed to operate according to a method as claimed in any one of claims 1 to 11.

5 15. A computer-readable storage medium storing computer-executable process steps for implementing a method as claimed in any one of claims 1 to 11.

10 16. A method for searching for objects in still or video images substantially as hereinbefore described with reference to the accompanying drawings.

17. A computer system substantially as hereinbefore described with reference to the accompanying drawings.

Method and Apparatus for Representing and Searching for an ObjectUsing Shape5     Abstract

10     A method of representing an object appearing in a still or video image for use in searching, wherein the object appears in the image with a first two-dimensional outline, by processing signals corresponding to the image, comprises deriving a view descriptor of the first outline of the object and deriving at least one additional view descriptor of the outline of the object in a different view, and associating the two or more view descriptors to form an object descriptor.

15

Abstract Figure No. 1

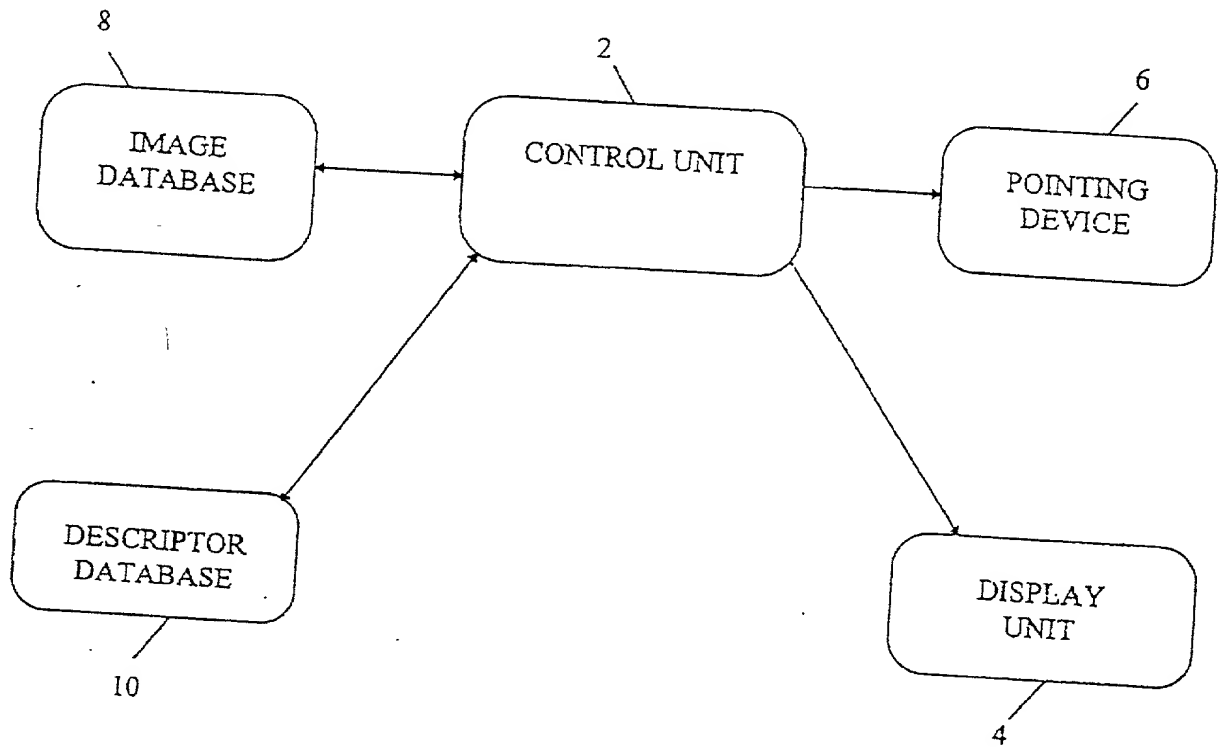


FIGURE 1

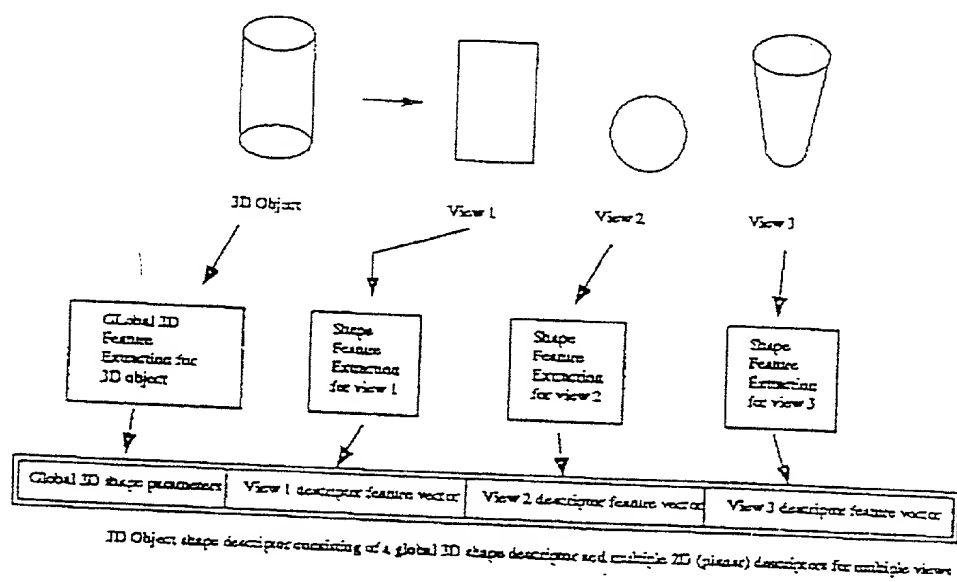


FIGURE 2

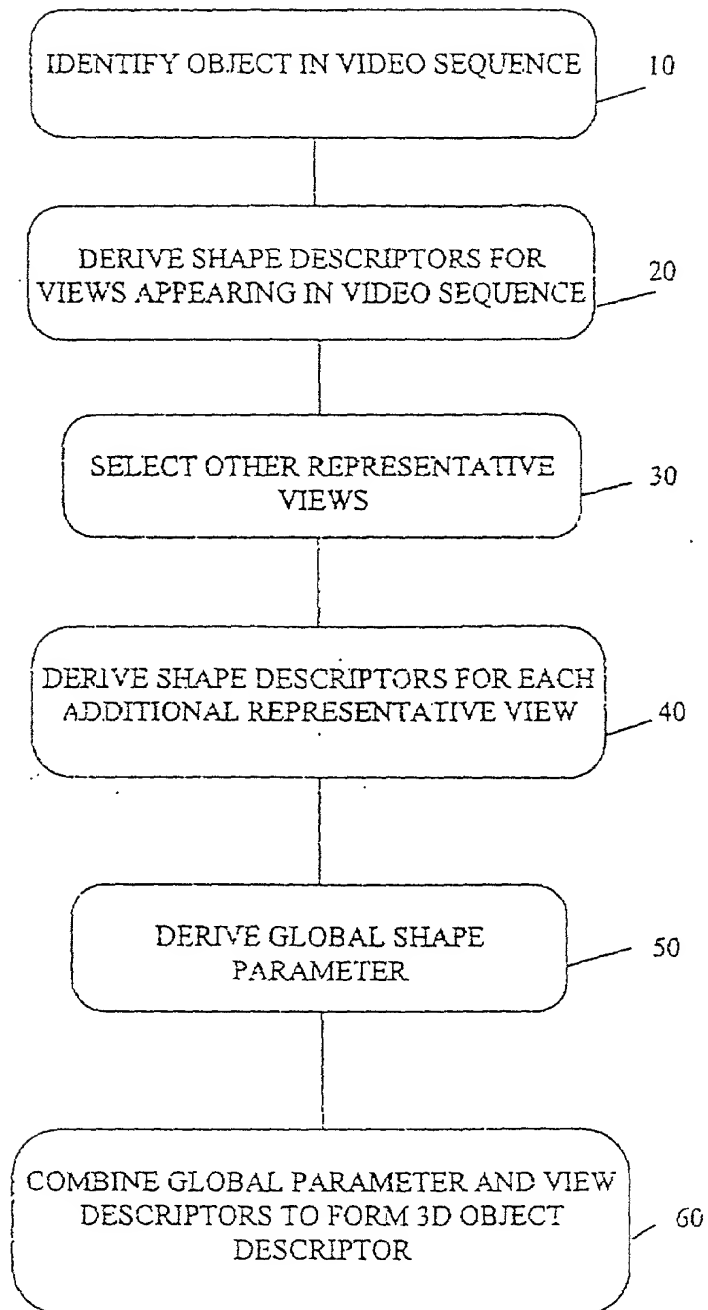


FIGURE 3



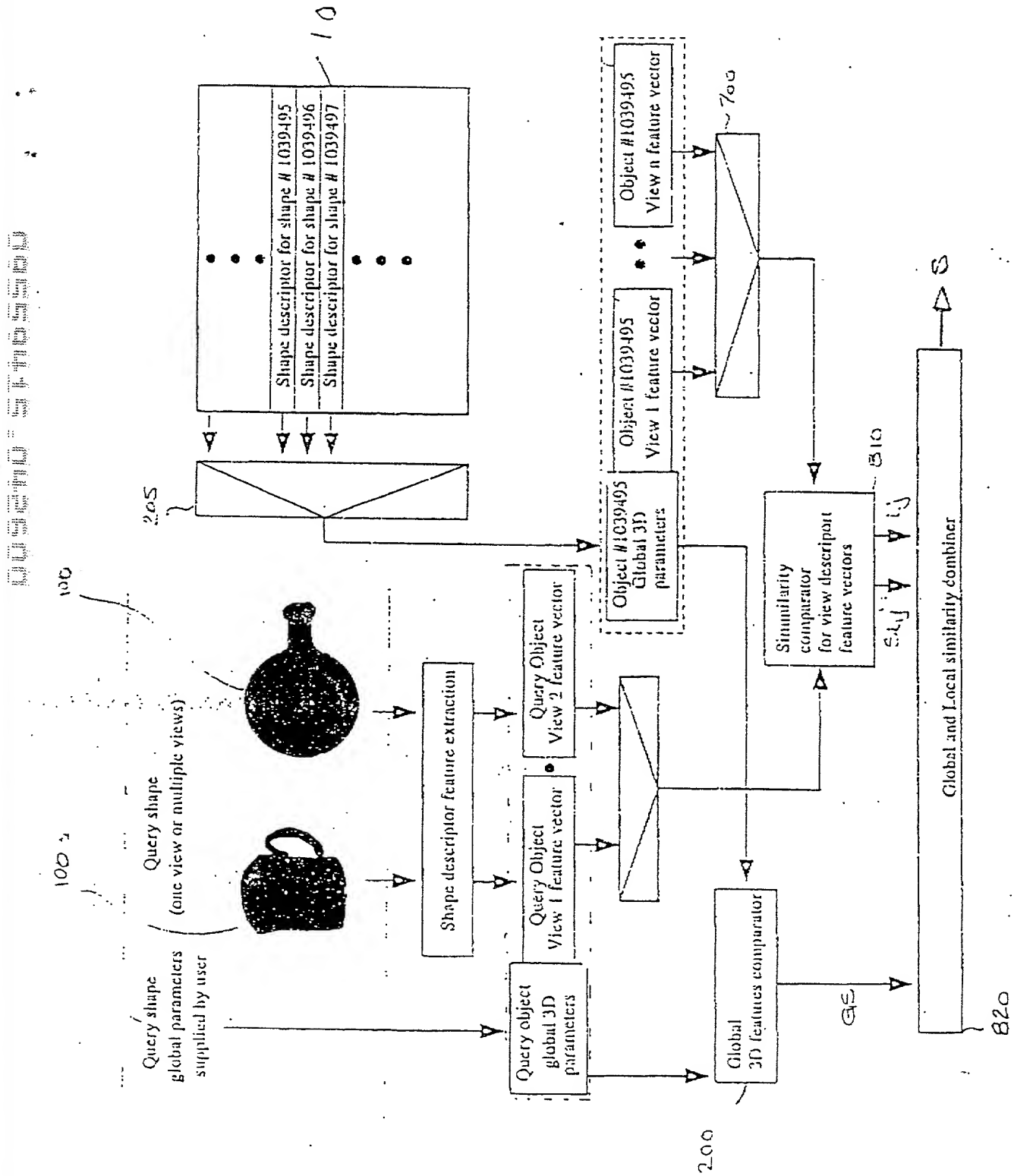


FIGURE 4.

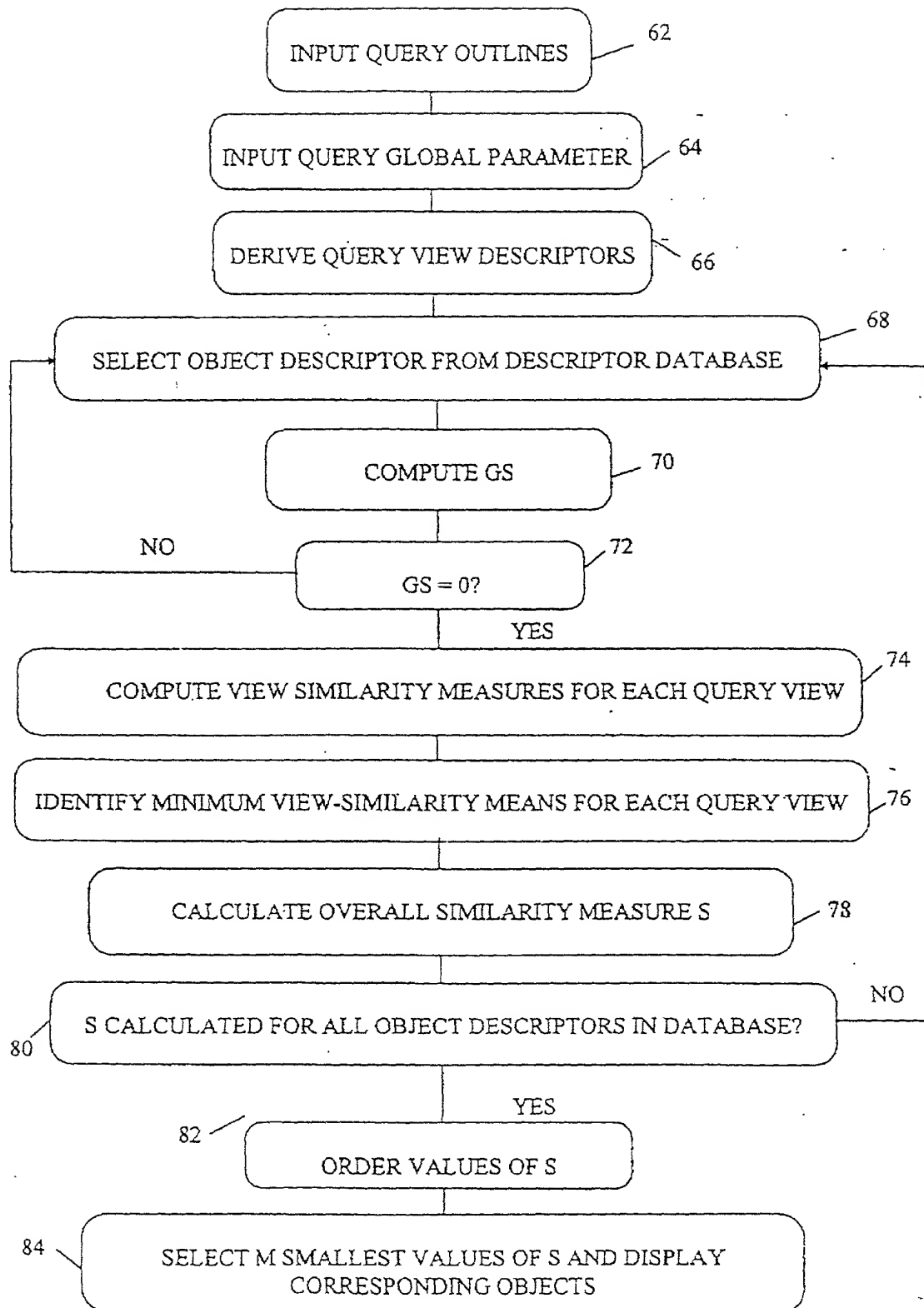


FIGURE 5

## Declaration and Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

## Japanese Language Declaration

## 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者（下記の名称が複数の場合）であると信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

METHOD AND APPARATUS FOR REPRESENTING AND  
SEARCHING FOR AN OBJECT USING SHAPE

上記発明の明細書は、

- ☐ 本書に添付されています。
- ☐ \_\_\_\_月\_\_\_\_日に提出され、米国出願番号または特許協定条約国際出願番号を\_\_\_\_とし、  
(該当する場合) \_\_\_\_に訂正されました。

the specification of which

- ☒ is attached hereto.
- ☐ was filed on \_\_\_\_\_  
as United States Application Number or  
PCT International Application Number  
\_\_\_\_\_ and was amended on  
\_\_\_\_\_ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration  
(日本語宣言書)

私は、米国法典第35編119条 (a) - (d) 項又は365条 (b) 項に基づき下記の、米国以外の国の少なくとも一か国を指定している特許協力条約365 (a) 項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

Prior Foreign Application(s)  
外国での先行出願

9909963.2	Gt. Britain
(Number) (番号)	(Country) (国名)
(Number) (番号)	(Country) (国名)

私は、第35編米国法典119条 (e) 項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

(Application No.) (出願番号)	(Filing Date) (出願日)
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I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Claimed  
優先権主張

29 / 04 / 1999	<input checked="" type="checkbox"/> <input type="checkbox"/>
(Day/Month/Year Filed) (出願年月日)	Yes <input type="checkbox"/> No <input type="checkbox"/> はい いいえ
(Day/Month/Year Filed) (出願年月日)	Yes <input type="checkbox"/> No <input type="checkbox"/> はい いいえ

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)
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I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)
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(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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# Japanese Language Declaration (日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の  
手続きを米特許商標局に対して遂行する弁理士または代理人  
として、下記の者を指名いたします。(弁理士、または代理  
人の氏名及び登録番号を明記のこと)

TERRELL C. BIRCH (Reg. No. 19,382)  
RAYMOND C. STEWART (Reg. No. 21,066)  
JOSEPH A. KOLASCH (Reg. No. 22,463)  
ANTHONY L. BIRCH (Reg. No. 26,122)

JAMES M. SLATTERY (Reg. No. 28,380)  
BERNARD L. SWEENEY (Reg. No. 24,448)  
MICHAEL K. MUTTER (Reg. No. 29,680)  
CHARLES GORENSTEIN (Reg. No. 29,271)

POWER OF ATTORNEY: As a named inventor, I hereby appoint  
the following attorney(s) and/or agent(s) to prosecute this  
application and transact all business in the Patent and Trademark  
Office connected therewith (list name and registration number)

GERALD M. MURPHY (Reg. No. 28,977)  
LEONARD R. SVENSSON (Reg. No. 30,330)  
TERRY L. CLARK (Reg. No. 32,644)  
ANDREW D. MEIKLE (Reg. No. 32,868)

MARC S. WEINER (Reg. No. 32,181)  
ANDREW F. REISH (Reg. No. 33,443)  
JOE M. MUNCY (Reg. No. 32,334)  
C. JOSEPH FARACI (Reg. No. 32,350)

書類送付先

Send Correspondence to:

BIRCH, STEWART, KOLASCH & BIRCH, LLP  
P.O. BOX 747  
FALLS CHURCH, VA 22040-0747  
TEL: (703) 205-8000

直接電話連絡先： (名前及び電話番号)

Direct Telephone Calls to: (name and telephone number)

BIRCH, STEWART, KOLASCH & BIRCH, LLP  
TEL: (703) 205-8000

唯一または第一発明者名		Full name of sole or first inventor	
		Miroslaw Z. Bober	
発明者の署名	日付	Inventor's signature	Date
		<i>Miroslaw Z. Bober</i>	4 April 2000
住所		Residence	
		Surrey, U.K.	
国籍		Citizenship	
		Poland	
私書箱		Post Office Address	
		18-20, Frederick Sanger Road, The Surrey	
		Research Park, Guildford, Surrey	
		GU2 6YD U.K.	
第二共同発明者		Full name of second joint inventor, if any	
第二共同発明者	日付	Second inventor's signature	Date
住所		Residence	
国籍		Citizenship	
私書箱		Post Office Address	

(第三以降の共同発明者についても同様に記載し、署名をす  
ること)

(Supply similar information and signature for third and subsequent  
joint inventors.)